

Final Report

Arizona Game & Fish Department

Heritage Project

I93025

SPINEDACE STREAM  
SURVEY

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## INTRODUCTION

The Little Colorado spinedace (*Lepidomeda vittata*) was listed as a threatened species in 1987 under the authority of the Endangered Species Act of 1973 (USFWS 1987). Possible reasons for the decline of this species include reduction in streamflow, use of ichthyotoxins, interactions with introduced species (Minckley and Carufel 1967), and predation by exotic fishes (Blinn *et al.* 1993). More recently, White (1995) suggests that crayfish prey on spinedace eggs and can influence the use of habitats by spinedace. This native Arizona fish occurs only in disjunct population in the Little Colorado River system, including Nutrioso Creek in Apache County, Arizona.

In 1993, the Springerville Ranger District, was awarded Heritage Grant funds to survey five streams on the Apache-Sitgreaves National Forests to determine presence or absence of Little Colorado spinedace and to determine the habitat condition of those streams. The five creeks surveyed with this grant were Rudd Creek, Nutrioso Creek, Auger Creek, Colter Creek and Benton Creek. In addition, Paddy Creek and Milk Creek were surveyed. Habitat conditions were measured using the General Aquatic Wildlife System (GAWS) methodology (USFS 1985). Fish population surveys were conducted using backpack electroshocking equipment. A crew of three Forest Service biological technicians and two Arizona Game & Fish Department fisheries interns (Pinetop Region) worked cooperatively to complete the surveys.

Of the seven streams surveyed, only Rudd Creek and Nutrioso Creek had spinedace populations. No fish were found on Milk Creek and Auger Creek. This report summarizes data collected during 1994 on Rudd Creek, Nutrioso Creek, Auger Creek, Colter Creek and Benton Creek.

## Survey Information

### Rudd Creek

Rudd Creek, in Apache County on the Apache-Sitgreaves National Forests, is a 19.5 kilometer (12.1 mile) northeasterly flowing tributary of Nutrioso Creek. The drainage area of this system is approximately 45 square kilometers ( 28 square miles), ranging in elevation from 2225 meters ( 7300 feet) near the confluence to a maximum of 2438 meters ( 8800 feet) at station 40, the uppermost stream area surveyed during the present inventory.

Rudd Creek is a second order stream that originates from spring flow in a meadow then flows alternately through meadow and canyon reaches en route to its Nutrioso Creek confluence, in SW1/4, SW1/4, Section 20, Township 8N, Range 30E. The stream's watershed ranges from pinon-juniper to spruce-fir vegetation types. At base flow, it is a narrow, shallow stream, with a mean width of 1.79 meters (5.9 feet), a mean depth of 0.09 meters (0.3 feet), and an overall width to depth ratio of 30.5. The average stream gradient was 4.2 percent. Rudd Creek supports a riparian area estimated to be 1.21 hectares (3 acres) in size and had an overall rating of 7 on the riparian scorecard that is fair.

Rudd Creek was divided into eight discrete reaches for sampling purposes (see Appendix A). Each reach consisted of three to six sampling stations, depending on the total length of the reach. Reaches between 500-1500 meters have three stations and reaches greater than 1500 meters have six stations (sometimes more). Each station is 50 meters in length, and consist of five perpendicular-to-flow transects at 10 meter intervals.

The Habitat Condition Index (HCI) is a multi variate rating of existing trout habitat quality. Studies show that spinedace may be trout-like in behavior and habitat requirements

(Minckley and Carufel 1967). Reach 1 had an average HCI of 64.6%, which is above the Forests' minimum standard of 60%. Reach 2 had an average HCI of 55.5%. The average HCI for reach 3 was 45.3%. A portion of reach 3 and all of reach 4 are on Arizona Game & Fish Department property (Sipe White Mountain Wildlife Area). The HCI for reach 4 averaged 50.2%. Reach 5 had an average HCI of 60.4%. Reach 6 had an HCI of 53.4%. The average HCI of reach 7 was only 33.7%. This reach had very little water and was not fish habitat. Reach 8 had an average HCI of 53.3%. See Table 1 for a summary of habitat conditions on Rudd Creek. Station photographs can be found in Appendix C.

In addition to collecting habitat data, fish data were collected using a backpack electroshocker. Spinedace were only found in reaches 1, 2, and the first two stations of reach three. Very few spinedace were found in the Sipe White Mountain Wildlife Area. Fish found to co-occur with the spinedace were bluehead mountain suckers (*Pantosteus discobolus*) and speckled dace (*Rhinichthys osculus*). No trout were found in stations in the first four reaches of Rudd Creek. Rainbow trout (*Oncorhynchus mykiss*) and brook trout (*Salvelinus fontinalis*) were found in reaches 5, 6, and 8. No fish were found in reach 7. A summary of fish collection data is presented in Table 2 and in Appendix B, Figures 1 through 6.

### Nutrios Creek

Nutrios Creek, in Apache County on the Apache-Sitgreaves National Forests, is a 35.6 kilometer (22 mile) north flowing tributary of the Little Colorado River. The drainage area of this watershed is approximately 432 square kilometers (167 square miles), and Nutrios Creek ranges in elevation from 2194 meters (7198 feet) (on the Forest) to 2491 meters (8173 feet) at station 30, the uppermost stream area surveyed during the present inventory.

Nutrios Creek is a third order stream that originates from spring flow in a meadow then

Table 1. Summary of Habitat Conditions on Rudd Creek, 1994.

Stream Reach:	1	2	3	4	5	6	7	8	Stream Ave. or Total
Reach Length (m)	548	1825	1736	3442	9000	1000	990	1746	20,287 total
Reach Area (m <sup>2</sup> )	216	278	457.5	614.5	455	240.5	184.5	388	2,834 total
Number of Stations	3	6	6	6	7	3	3	6	40 total
Elevation (m)	2249	2255	2286	2286	2450	2591	2591	2621	2416
Gradient (%)	1.6	1.3	1.0	1.3	3.5	8.3	8.0	8.2	4.2
Riffle (%)	40.7	69.8	80.5	73.2	71.9	93.9	95.4	84.2	76.2
Potential Spawning Area (PSA%)	8.9	6.4	8.3	0.9	37.6	22	6.0	3.5	11.7
Potential Rearing Area (PRA%)	58.5	47.5	16.5	20.7	33.4	5.2	0	15.7	24.7
Channel Width (m)	7.5	11.4	14.6	13.6	11.2	11.0	6.3	7.2	10.35
Water Width (m)	1.8	1.2	2.0	2.6	1.6	2.0	1.5	1.60	1.79
Water Depth (m)	0.09	0.15	0.10	0.13	0.14	0.04	0.02	0.04	0.09
Water Width/depth Ratio <sup>1</sup>	20	8	20	20	11	50	75	40	30.5
Pool Measure (%) <sup>2</sup>	81.4	30.0	29.3	30.1	46.7	12.3	0	31.4	32.65
Pool Structure (%) <sup>2</sup>	80.9	42.9	50.0	66.7	42.9	33.3	0	50.0	45.84
Gravel Bottom (%) <sup>3</sup>	29.5	14.9	17.2	2.1	61.6	71.3	22.8	56.0	34.43
Bank Cover (%) <sup>2</sup>	64.2	50.0	47.5	58.3	67.5	76.7	71.7	68.8	63.09
Bank Soil Stability (%) <sup>3</sup>	61.7	96.7	62.9	71.7	70.0	62.5	49.2	55.4	66.26
Bank Veg. Stability (%) <sup>3</sup>	70.0	98.3	65.0	72.1	73.6	64.2	58.3	58.3	69.98
Canopy Density (%) <sup>3</sup>	47	2	3	21	80	71	53	68.5	43.19
Ungulate Damage (%) <sup>4</sup>	3	4.9	19.0	36.9	6.8	18.5	3.3	0	92.4
Embeddedness (%) <sup>4</sup>	80	78.2	77.1	78.8	40.7	20.9	41.5	34.7	56.49
Habitat Condition Index (HCI%) <sup>5</sup>	64.6	55.5	45.3	50.2	60.4	53.4	33.7	53.3	52.05
Habitat Vulnerability Index (HVI%) <sup>6</sup>	61.4	57.3	56.2	49.62	53.64	50.91	46.67	43.79	52.44
Riparian Condition <sup>7</sup>	7	6	5	4	10	8	8	9	7
Riparian Area (ha)	0.02	0.14	0.07	0.53	0.11	0.04	0.15	0.15	1.2

<sup>1</sup> - <15 Good; 16-25 Fair; >26 Poor<sup>2</sup> - >70% Good; 40-69% Fair; <39% Poor<sup>3</sup> - >80% Good; 40-79% Fair; <39% Poor<sup>4</sup> - <25% Good; 26-50% Fair; >51% Poor<sup>5</sup> - >60% Good; 40-59% Fair; <39% Poor<sup>6</sup> - <45% Good; 46-59% Fair; >60% Poor<sup>7</sup> - 9-12 Moderately High - High; 6-8 Moderate; 0-5 Low - Moderately Low

Table 2. Number, relative abundance, relative biomass, and catch per effort of fish sampled by electrofishing at Rudd Creek in 1994.

Reach	Species Sampled	No. Sampled	Percent of Total	Catch Per Effort	Weight Sampled (g)	Percent of Total	Size Range (mm)
1	LEVI	36	37.5	24.00	13	25.49	26-75
	PADI	11	11.46	7.33	11	21.57	35-56
	RHOS	49	51.04	32.66	27	52.74	25-79
	TOTAL	96	100	64.0	51	100	
2	LEVI	96	27.27	32.00	318	38.49	20-102
	PADI	45	12.78	15.00	293	35.47	40-140
	RHOS	211	59.94	70.33	215	26.02	25-95
	TOTAL	352	100	117.33	826	100	
3	LEVI	161	30.96	46.00	366	30.42	25-132
	PADI	61	11.73	17.42	550	45.72	35-155
	RHOS	298	57.31	85.14	287	23.86	22-85
	TOTAL	520	100	148.60	1203	100	
4	RHOS	11	100	3.66	62	100	42-102
5	ONMY	73	69.52	20.86	1839	81.73	57-240
	SAFO	32	30.47	9.14	411	18.26	64-144
	TOTAL	105	100	30.00	2250	100	
6	ONMY	17	32.69	11.33	394	37.78	45-210
	SAFO	35	67.30	23.33	649	62.22	30-176
	TOTAL	52	100	34.66	1043	100	
7	NO FISH	-----	-----	-----	-----	-----	-----
8	ONMY	1	33.33	.33	77	31.42	180
	SAFO	2	66.66	.66	168	68.60	183-191
	TOTAL	3	100	1.0	245	100	

LEVI = *Lepidomeda vittata* (Little Colorado Spinedace)

PADI = *Pantosteus discobolus* (Bluehead Sucker)

RHOS = *Rhinichthys osculus* (Speckled dace)

ONMY = *Oncorhynchus mykiss* (Rainbow trout)

SAFO = *Salvelinus fontinalis* (Brook trout)



flows alternately through meadow and canyon reaches en route to its confluence at the Little Colorado River in NW1/4, Section 29, Township 9N, Range 29E. The stream's watershed ranges from open grassland to spruce-fir vegetation types. On the Forest, the creek has a mean water width of 1.6 meters (5.2 feet), a mean depth of 0.09 meters (0.29 feet), and an overall width-to-depth ratio of 22.7. The average stream gradient was five percent. Nutrioso Creek supports a riparian area estimated to be 0.38 hectares (0.9 acres) in size (on the Forest only) and had an overall rating of 7.7 on the riparian scorecard that is fair.

Nutrioso Creek was divided into six discrete reaches for sampling purposes (see Appendix A). The reach of Nutrioso Creek from above Nelson Reservoir through the town of Nutrioso was not surveyed, as this reach is within private land on the Forest. Each reach consisted of three to six sampling stations, depending on the length of the reach. Reaches with a total length between 500 and 1500 meters have three stations and reaches greater than 1500 meters have six stations. Each station is 50 meters in length and consists of five perpendicular-to-flow transects at 10 meter intervals.

A habitat condition index was determined for each reach on Nutrioso Creek. Reach 1 had an average HCI of 45.4%, which is below the Forest's minimum standard of 60%. Reach 2 also had a substandard HCI of 50.8%. The average HCI for reach 3 was also low (42.4%). Reach 4 had an average HCI of 53.5%. The HCI for reach 5 averaged 55.8% (the highest HCI for the stream). Reach 6 had an HCI of 51.0%, and the mean HCI for the stream was 49.8%. Table 3 is a summary of habitat conditions on Nutrioso Creek in 1994. Station photographs can be found in Appendix C.

Fish data were also collected on Nutrioso Creek using a backpack electroshocker. Spinedace were only found in those reaches below Nelson Reservoir (reaches 1, 2, and 3). Fish species found to co-occur with spinedace in Nutrioso creek (in reaches 1, 2, and 3) were bluehead mountain suckers, speckled dace, fathead minnows (*Pimephales promelas*), rainbow trout, brook trout, cutthroat trout (*Oncorhynchus clarki*), and green sunfish (*Lepomis cyanellus*). No fish were found in reach 4 of Nutrioso Creek. Rainbow trout, brook trout, and speckled dace were found in reach 5. One rainbow trout was found in reach six. A summary of fish collection data is presented in Table 4 and in Appendix B, Figures 7 through 14.

Table 3. Summary of Habitat Conditions on Nutrioso Creek, 1994.

Stream Reach	1	2	3	4	5	6	Stream Ave. or Total
Reach Length (m)	4536	4166	2117	1420	1720	924	14,703 meters on ASNF
Reach Area (m <sup>2</sup> )	294.5	737.0	598.5	89.5	361	70.5	2151m <sup>2</sup>
Number of Stations	6	6	6	3	6	3	30
Elevation (m)	2194	2225	2255	2418	2463	2491	2341
Gradient (%)	1.0	1.0	1.2	1.7	2.8	4	1.95
Riffle (%)	17.4	21.1	4.1	55.1	40.8	69.1	34.6
Potential Spawning Area (PSA%)	7.7	5.2	2.9	18.4	28.6	9.6	12.1
Potential Rearing Area (PRA%)	65.9	85.1	95.9	13.2	18.4	31.2	51.6
Channel Width (m)	8.4	8.8	6.9	3.6	4.0	4.0	5.95
Water Width (m)	1.2	3.0	2.5	0.8	1.5	0.6	1.6
Water Depth (m)	0.05	0.14	0.17	0.02	0.05	0.03	0.09
Water Width/depth Ratio <sup>1</sup>	24	20	2.33	40	30	20	22.7
Pool Measure (%) <sup>2</sup>	34.8	24.5	8.3	23.2	14.3	51.5	26.1
Pool Structure (%) <sup>2</sup>	50.0	94.6	83.3	33.3	16.7	0	46.3
Gravel Bottom (%) <sup>2</sup>	31.3	22.2	5.1	54.3	76.2	10.6	33.3
Bank Cover (%) <sup>2</sup>	53.3	64.2	42.9	70.8	75.4	81.7	64.7
Bank Soil Stability (%) <sup>3</sup>	48.3	50.0	60.8	69.2	73.8	80.8	63.8
Bank Veg. Stability (%) <sup>3</sup>	54.6	49.2	54.2	70.0	78.3	81.7	64.7
Canopy Density (%) <sup>4</sup>	13.7	5.45	3.7	85.3	86	69.7	44
Ungulate Damage (%) <sup>4</sup>	5.8	29.6	30.8	2.8	2.9	5.4	12.9
Embeddedness (%) <sup>4</sup>	44.7	76.6	70	24.6	42.7	68.4	54.5
Habitat Condition Index (HCI%) <sup>5</sup>	45.4	50.8	42.4	53.5	55.8	51.0	49.8
Riparian Condition <sup>6</sup>	8	7	6	9	10	6	7.7
Riparian Area (ha)	0.07	0.11	0.10	0.02	0.06	0.02	0.38

<sup>1</sup> - <15 Good; 16-25 Fair; >26 Poor<sup>2</sup> - >70% Good; 40-69% Fair; <39% Poor<sup>3</sup> - >80% Good; 40-79% Fair; <39% Poor<sup>4</sup> - <25% Good; 26-50% Fair; >51% Poor<sup>5</sup> - >60% Good; 40-59% Fair; <39% Poor<sup>6</sup> - 9-12 Moderately High - High; 6-8 Moderate; 0-5 Low - Moderately Low

Table 4. Number, relative abundance, relative biomass, and catch per effort of fish sampled by electrofishing at Nutrioso Creek in 1994.

Reach	Species Sampled	No. Sampled	Percent of Total	Catch per Effort	Weight Sampled (g)	Percent of Total	Size Range (mm)
1	LEVI	18	5.47	6.0	44	14.81	52-68
	PADI	17	5.16	5.66	130	43.77	70-125
	PIPR	1	0.30	0.33	3	1.01	62
	RHOS	293	89.06	97.66	120	40.40	15-80
	TOTAL	329	100	109.66	297	100	
2	ONMY	1	0.04	0.33	250	13.97	306
	SAFO	1	0.04	0.33	254	14.20	280
	LEVI	310	11.52	103.33	296	16.54	23-105
	PADI	1769	65.74	589.66	807	45.10	30-135
	PIPR	48	1.80	16.00	69	3.86	40-71
	RHOS	562	20.88	187.33	113	6.31	18-70
	TOTAL	2691	100	897.00	1789	100	
3	ONCL	3	0.30	1.00	61	3.02	175-200
	ONMY	2	0.20	0.66	345	17.10	265-292
	SAFO	3	0.30	1.00	262	13.00	195-240
	LEVI	107	11.00	35.66	239	11.84	50-120
	PADI	632	64.82	210.66	867	43.00	38-183
	PIPR	158	16.21	52.66	71	3.52	23-60
	RHOS	69	7.10	23.00	61	3.02	26-77
	LECY	1	0.10	0.33	111	6.0	172
	TOTAL	975	100	325.00	2017	100	
4	NO FISH	-----	-----	-----	-----	-----	-----
5	ONMY	90	95.74	30.00	1002	89.22	37-215
	SAFO	1	1.06	0.33	118	10.50	235
	RHOS	3	3.20	1.00	3	0.27	45-50
	TOTAL	94	100	31.33	1123	100	
6	ONMY	1	100	100	9	100	98

LEVI = *Lepidomeda vittata* (Little Colorado Spinedace)

PADI = *Pantosteus discobolus* (Bluehead Sucker)

PIPR = *Pimephales promelas* (Fathead Minnow)

RHOS = *Rhinichthys osculus* (Speckled dace)

ONMY = *Oncorhynchus mykiss* (Rainbow trout)

LECY = *Lepomis cyanellus* (Green Sunfish)

SAFO = *Salvelinus fontinalis* (Brook trout)

ONCL = *Oncorhynchus clarki* (Cutthroat trout)

### Benton Creek

Benton Creek, in Apache County on the Apache-Sitgreaves National Forests, is a 7.6 kilometer (4.7 mile) northeasterly flowing tributary of Rudd Creek. The drainage area of this system is approximately 8.9 square kilometers (5.5 square miles), and Rudd Creek ranges in elevation from 2414 meters (7920 feet) near the confluence, to a maximum of 2599 meters (8527 feet) at station 18, the uppermost stream area surveyed.

Benton Creek is a second order stream that originates from spring flow in a meadow, then flows through canyon and meadow reaches en route to its Rudd Creek confluence, in SW¼, SW¼, Section 10, Township 7N, Range 29E. The streams watershed ranges from ponderosa pine to mixed conifer vegetation types. At base flow, it is a narrow, shallow stream, with a mean width of 1.08 meters (3.5 feet), a mean depth of 0.03 meters (0.1 feet), and a mean width-to-depth ratio of 39.6. The average stream gradient was 6 percent. Benton Creek supports a riparian area estimated to be 0.33 hectares (0.82 acres) in size and has an overall rating of 9.8 on the riparian scorecard which is good.

Benton Creek was divided into five reaches for sampling purposes (see Appendix A). Reach 1 had six sampling stations, while the remaining four reaches had three sampling stations each. A habitat condition index was determined for each of these reaches. Reach 1 had an average HCI of 44.9%, which is below the Forest minimum standard of 60%. Reach 2 had an average HCI of 48.1%. Reach 3 had an HCI of 56.6%. Reaches 4 and 5 also had substandard HCI's of 58.4% and 42.6% respectively. Table 5 is a summary of habitat conditions on Benton Creek in 1994. Appendix C contains station photographs for Benton Creek.

Fish data were also collected on Benton Creek using a backpack electroshocker. No Little Colorado spinedace were found in Benton Creek. Rainbow trout were found in Reaches 1, 3, and 4. No fish were found in reaches 2 and 5. A summary of fish collection data is presented in Table 6 and Appendix B, Figures 15-16..

### Colter Creek

Colter Creek, in Apache County on the Apache-Sitgreaves National Forest is a 16.1 kilometer (10 mile) northeasterly flowing tributary of Nutrioso Creek. The drainage area of this system is approximately 25.9 square kilometers (16.1 square miles), ranging in elevation from 2408 meters (7901 feet) at the Forest

Table 5. Summary of Habitat Conditions on Benton Creek, 1994.

Stream Reach	1	2	3	4	5	Stream Ave. Or Total
Reach Length (m)	1739	1424	1000	768	1135	6066
Reach Area (m <sup>2</sup> )	106.5	37.5	198.5	213.5	150.5	706.5
Number of Stations	6	3	3	3	3	18
Elevation (m)	2408	2499	2560	2636	2700	2561
Gradient (%)	2	5	6	10	7.5	6.1
Riffle (%)	12.3	33.3	85.5	93.2	100	64.9
Potential Spawning Area (PSA%)	1.6	17.7	13.5	8.6	7.3	9.74
Potential Rearing Area (PRA%)	59.4	6.7	16.9	8.6	0	18.3
Channel Width (m)	8.5	21.6	13.0	10.4	8.5	12.4
Water Width (m)	0.4	0.4	1.6	1.8	1.2	1.08
Water Depth (m)	0.03	0.01	0.04	0.04	0.02	0.03
Water Width/depth Ratio <sup>1</sup>	13	40	40	45	60	39.6
Pool Measure (%) <sup>2</sup>	40.6	0	29.1	13.7	0	16.7
Pool Structure (%) <sup>2</sup>	50.0	0	66.7	33.3	0	30
Gravel Bottom (%) <sup>2</sup>	8.6	42	90.3	88.1	86.7	63.1
Bank Cover (%) <sup>2</sup>	52.1	86.7	51.7	78.3	80.0	69.8
Bank Soil Stability (%) <sup>3</sup>	58.3	75.8	51.7	63.3	43.3	58.5
Bank Vegetation Stability (%) <sup>3</sup>	59.6	84.2	50.0	73.3	45.8	62.6
Canopy Density (%) <sup>3</sup>	29	87	90	58.4	42.6	61.4
Ungulate Damage (%) <sup>4</sup>	0	0	2.1	1.0	0	0.62
Embeddedness (%) <sup>4</sup>	62	49.6	35.0	35.1	17.1	39.8
Habitat Condition Index (%) <sup>5</sup>	44.9	48.1	56.6	58.4	42.6	50.1
Habitat Vulnerability Index (%) <sup>6</sup>	49.8	54.4	47.1	45.9	38.2	47.1
Riparian Condition <sup>7</sup>	7	10	10	11	11	9.8
Riparian Area (ha)	0.06	0.10	0.06	0.04	0.07	0.33

<sup>1</sup> - <15 Good; 16-25 Fair; >26 Poor<sup>2</sup> - >70% Good; 40-69% Fair; <39% Poor<sup>3</sup> - >80% Good; 40-79% Fair; <39% Poor<sup>4</sup> - <25% Good; 26-50% Fair; >51% Poor<sup>5</sup> - >60% Good; 40-59% Fair; <39% Poor<sup>6</sup> - <45% Good; 46-59% Fair; >60% Poor<sup>7</sup> - 9-12 Moderately High - High; 6-8 Moderate; 0-5 Low - Moderately Low

Table 6. Number, relative abundance, relative biomass, and catch per effort of fish sampled by electrofishing at Benton Creek in 1994.

Reach	Species Sampled	No. Sampled	Percent of Total	Catch Per Effort	Weight Sampled (g)	Percent of Total	Size Range (mm)
1	ONMY	4	100	1.33	116	100	21-104
2	NONE						
3	ONMY	17	100	11.33	514	100	80-212
4	ONMY	11	100	7.33	384	100	90-185
5	NONE						

ONMY = *Oncorhynchus mykiss* (Rainbow trout)

Table 7. Number, relative abundance, relative biomass, and catch per effort of fish sampled by electrofishing at Colter Creek in 1994.

Reach	Species Sampled	No. Sampled	Percent of Total	Catch per Effort	Weight Sampled (g)	Percent of Total	Size Range (mm)
1	ONMY	33	56	11	688	83.7	60-225
	RHOS	26	44	8.7	134	16.3	53-101
	Total	59	100	19.7	822	100	
2	ONMY	72	100	48	1229	100	62-245
3	ONMY	63	100	42	959	100	41-175
4	ONMY	78	100	26	648	100	36-227
5	NONE						
6	ONMY	25	100	8.33	293	100	64-178
7	NONE						
8	NONE						
10	ONMY	2	100	1.33	51	100	116-140

ONMY = *Oncorhynchus mykiss* (Rainbow trout)

RHOS = *Rhinichthys osculus* (Speckled dace)

Boundary; to 2682 meters (8799.6 feet) on its highest fork.

Colter Creek is a second order stream that originates from spring flows through meadow and canyon reaches en route to its Nutrioso Creek confluence in NE¼, SE¼, T7N, R30E, Section 29. The stream's watershed ranges from ponderosa pine to spruce-fir vegetation types. At base flow, it is a narrow, shallow stream, with a mean width of 2.3 meters (7.5 feet), a mean depth of 0.05 meters (0.16 feet) and a mean width-to-depth ratio of 46. The average stream gradient was 7.8 percent. Colter Creek supports a riparian area estimated to be 0.68 hectares (1.7 acres) in size and has an overall rating of 8.1 which is fair.

Colter Creek was divided into ten reaches for sampling purposes (see Appendix A). Reaches 1, 4, 6, and 8 had six sampling stations each. Reaches 2, 3, 5, and 10 had three sampling stations each. Reach 7 had one station. Reach 9 was not surveyed because there was no discernable stream channel.

A habitat condition index was determined for each reach surveyed. The HCI for reach 1 was 42.8%. Reach 2 also had a substandard HCI of 53.7%. Reach 3 had a satisfactory HCI (66.8%). Reach 4 had an HCI of 58.4%, reach 5 scored 58.1%, and reach 6 had an HCI of 55.9%. Reach 7 had no water and scored 47.5%. Reach 8 had an unusually low HCI of 29.4 %. This score reflects the lack of fish habitat (in general) in the reach. Reach 8 and 9 are between Rogers Marsh and Rogers Reservoir, being dry most of the year except during snowmelt runoff. A summary of habitat conditions is presented in Table 8. Station photographs can be found in Appendix C.

Fish data were also collected on Colter Creek. There were no Little Colorado spinedace in Colter Creek. There were speckled dace in reach 1. Rainbow trout were found in all other reaches, except 5, 7, 8 and 9. Table 7 is a summary of fish collection data. There are also length-frequency distributions in Appendix B, Figures 17-19.

#### Auger Creek

Auger Creek, in Apache County on the Apache-Sitgreaves National Forest is a 12 kilometer (7.46 mile) north flowing tributary of Nutrioso Creek. The drainage area of this system is approximately 18 square kilometers (11.2 square miles), and Auger Creek ranges in elevation from 2408 meters (7900 feet) at the Forest

Table 8. Summary of Habitat Conditions on Colter Creek in 1994.

Stream Reach	1	2	3	4	5	6	7	8	10	Stream Ave. Or Total
Reach length (m)	2430	956	740	4400	1180	1630	543	2195	900	14,974
Reach Area (m <sup>2</sup> )	619	349	363	510	75	390	25	171	887	3389
Number of Stations	6	3	3	6	2	6	1	6	3	36
Elevation (m)	2390	2488	2591	2591	2710	2530	2590	2621	2560	2559
Gradient (%)	5.8	8	10.7	7.2	5.5	8.3	9	9	6	7.7
Riffle (%)	33.5	8.2	56.4	57.5	0	45.6	0	0	42.5	27.1
Potential Spawning Area (PSA %)	8.9	10.8	3.3	14.8	41.4	0	0	2.4	0.7	9.1
Potential Rearing Area (PRA%)	0	5.5	46.8	17.6	24.3	5.0	0	16.1	66.6	20.2
Channel Width (m)	22.3	12.2	12.2	10.4	9.5	8.1	1.5	5.2	9.7	10.1
Water Width (m)	2.7	3.0	2.9	2.1	0.9	2.0	0	0.7	6.6	2.3
Water Depth (m)	0.07	0.07	0.07	0.04	0.01	0.02	0	0.01	0.15	0.05
Water Width/depth Ratio <sup>1</sup>	39	43	41	52.5	90	100	0	70	44	53.3
Pool Measure (%) <sup>2</sup>	0	10.5	27.7	31.9	43.9	8.7	0	10.4	46.9	20
Pool Structure (%) <sup>2</sup>	0	33.3	33.3	66.7	100	16.7	0	0	100	38.9
Gravel Bottom (%) <sup>3</sup>	85.9	62.9	81.7	68.5	71.9	74.6	0	2.5	32.3	53.4
Bank Cover (%) <sup>2</sup>	72.9	82.5	99.2	78.3	46.3	83.3	95	51.7	61.7	74.5
Bank Soil Stability (%) <sup>3</sup>	71.7	82.5	90.8	65.4	56.3	77.1	95	56.3	56.7	72.4
Bank Veg. Stability (%) <sup>3</sup>	72.1	80	92.5	73.8	62.5	81.3	95	55.8	65.0	75.3
Canopy Density (%) <sup>3</sup>	54	56	64	55	2	48	0	1	38	35.3
Ungulate Damage (%) <sup>4</sup>	10.0	4.4	2.8	13	34.8	5.0	12.5	46.1	0.3	14.3
Embeddedness (%) <sup>4</sup>	20.0	24.9	31.8	36.2	47.7	1.8	100	77.9	58.6	44.3
Habitat Condition Index (%) <sup>5</sup>	50.4	58.6	70.9	64.1	63.5	57.0	47.5	29.4	60.4	55.8
Habitat Vulnerability Index (%) <sup>6</sup>	45.5	42.3	50.6	45	51.8	50.6	41.8	41.7	47.4	46.3
Riparian Condition <sup>7</sup>	11.2	11.3	11.3	9.7	1	12	4	3.8	8.7	8.9
Riparian Area (ha)	0.09	0.04	0.04	0.19	0.03	0.12	0	0.09	0.8	1.4

<sup>1</sup> - <15 Good; 16-25 Fair; >26 Poor<sup>2</sup> - >70% Good; 40-69% Fair; <39% Poor<sup>3</sup> - >80% Good; 40-79% Fair; <39% Poor<sup>4</sup> - <25% Good; 26-50% Fair; >51% Poor<sup>5</sup> - >60% Good; 40-59% Fair; <39% Poor<sup>6</sup> - <45% Good; 46-59% Fair; >60% Poor<sup>7</sup> - 9-12 Moderately High - High; 6-8 Moderate; 0-5 Low - Moderately Low



Table 9. A Summary of Habitat Conditions at Auger Creek in 1994.

Reach	1	2	3	4	5	Stream Ave. Or. Total
Reach Length (m)	448	390	422	450	460	2170
Reach Area (m <sup>2</sup> )	41.0	35.5	22.5	44	47.5	190.5
Number of Stations	1	1	1	1	1	5
Elevation (m)	2408	2408	2438	2438	2469	2432
Gradient (%)	2.5	9.0	9.5	8	10	7.8
Riffle (%)	0	0	25	0	15.5	8.1
Potential Spawning Area (%)	33.9	27.3	43.7	70.4	15.5	38.2
Potential Rearing Area (%)	27.1	0	34.4	0	0	12.3
Channel Width (m)	10.3	5.1	13.2	9.1	7.4	9.02
Water Width (m)	1.2	0.9	0.6	1.1	1.2	1
Water Depth (m)	0.06	0.10	0.07	0.02	0.05	0.06
Water Width/Depth Ratio <sup>1</sup>	20	9	8.6	55	24	23.3
Pool Measure (%) <sup>2</sup>	54.2	0	68.7	0	0	24.6
Pool Structure (%) <sup>2</sup>	100	0	100	0	0	40
Gravel Bottom (%) <sup>2</sup>	54.2	38.6	43.7	72.2	32.8	48.3
Bank Cover (%) <sup>2</sup>	35	60.0	57.5	45.0	60.0	51.5
Bank Soil Stability (%) <sup>2</sup>	35	60.0	57.5	42.5	60.0	51
Bank Veg. Stability (%) <sup>3</sup>	35	60.0	57.5	42.5	60.0	51
Canopy Density (%) <sup>3</sup>	58.0	62.0	48.0	87.0	85.0	68.0
Ungulate Damage (%) <sup>4</sup>	25.0	2.5	5.0	0	5.0	7.5
Embeddedness (%) <sup>4</sup>	72.0	56.0	44.0	36.0	60.0	53.6
Habitat Condition Index (%) <sup>5</sup>	52.2	36.4	64.2	33.7	35.5	44.4
Habitat Vulnerability Index (%) <sup>6</sup>	47.7	36.4	37.3	32.3	38.18	38.4
Riparian Condition <sup>7</sup>	10	10	10	10	10	10
Riparian Area (ha)	0	0	0.01	0.01	0.01	0.03

<sup>1</sup> - <15 Good; 16-25 Fair; >26 Poor<sup>2</sup> - >70% Good; 40-69% Fair; <39% Poor<sup>3</sup> - >80% Good; 40-79% Fair; <39% Poor<sup>4</sup> - <25% Good; 26-50% Fair; >51% Poor<sup>5</sup> - >60% Good; 40-59% Fair; <39% Poor<sup>6</sup> - <45% Good; 46-59% Fair; >60% Poor<sup>7</sup> - 9-12 Moderately High - High; 6-8 Moderate; 0-5 Low - Moderately Low

boundary to 2469 meters (8100 feet) at the uppermost stations.

Auger Creek is a first order stream that originates from spring flows through meadow and canyon reaches en route to its Nutrioso Creek confluence in SW $\frac{1}{4}$ , SW $\frac{1}{4}$ , T7N, R29E, Section 32. The streams watershed is in the ponderosa pine vegetation type. At base flow, it is a narrow shallow stream with a mean width of 1 meter (3.28 feet), a mean water depth of 0.06 meters (0.2 feet), and a mean width-to-depth ratio of 23.3. The average stream gradient was 7.8 percent. Auger Creek supports a riparian area estimated to be 0.03 hectares (0.07 acres) and has an overall riparian condition rating of 10 which is good.

Auger Creek was divided into five reaches for sampling purposes (see Appendix A). Each reach had one sampling station. The Habitat Condition Indexes for every reach was below the Forests' minimum standard of 60%, except reach 3. Auger Creek is known to become intermittent part of the year. A summary of habitat conditions is presented in Table 9. No fish were captured during electrofishing efforts on Auger Creek in 1994. Station photographs can be found in Appendix C.

### **Discussion**

The Nutrioso Creek Watershed is located in the northeast portion of the Apache National Forest, and Nutrioso Creek is a north flowing tributary of the Little Colorado River. Approximately one-tenth (16 square miles) of the 167 square mile watershed is private land, most of which is located along Nutrioso Creek from Nelson Reservoir upstream to the town of Nutrioso. All of the streams surveyed in this study had portions within private land. Current and past land use activities on the watershed have primarily been livestock grazing, logging, and recreational activities such as dispersed camping, fishing, and hunting. Presently most fishing occurs in Nelson Reservoir and within Nutrioso Creek downstream of Nelson Reservoir. Approximately 15-20,000 catchable rainbow trout are stocked annually into Nelson Reservoir, primarily during the heavy use months of summer.

The Apache-Sitgreaves National Forests Land Management Plan recognized the important and distinctive values of riparian areas by setting standards and goals for riparian and fisheries habitat (USFS 1989). The Forest Plan calls for managing and maintaining at least 60% of potential habitat capability for threatened

and endangered species and cold water fisheries. All of the stream reaches surveyed were either cold water fisheries or occupied by the threatened Little Colorado spinedace. There were a total of 33 stream reaches surveyed; nine on Colter Creek, five on Auger Creek, five on Benton Creek, six on Nutrioso Creek, and eight on Rudd Creek. Of the 33 reaches surveyed, only five (15%) were above the minimum 60% HCI. Two were on Colter Creek, one on Auger Creek, and two on Rudd Creek. The average HCI of all the 33 stream reaches surveyed was 50.4%. Of the 33 reaches surveyed, 21 were A-channel types, three were B-channel types, and nine were C-channel types. Three (14%) of the A-channel types were above the minimum 60% HCI, one (33%) of the B-channel types were above the minimum 60% HCI, and one (15%) of the C-channel types were above the minimum 60% HCI. These low HCI values can be attributed to several factors; high width-to-depth ratios, low pool quantity and quality, low bank cover and stability, high substrate embeddedness, and low riparian condition.

Little Colorado spinedace were found in the first three reaches of both Nutrioso and Rudd Creeks. Only one of these reaches, reach 1 on Rudd Creek, had an HCI of at least 60%. The average HCI for these six stream reaches was 52.3%. All of these reaches have undergone channel downcutting, widening, and headcutting, resulting in heavy sediment loading and unvegetated and unstable stream banks. Little Colorado spinedace abundance showed no correlations to any GAWS or habitat parameters, although Little Colorado spinedace biomass and water depth appear to be positively correlated (no statistical analysis). Overall trout biomass for the streams surveyed averaged only 1.83 grams per square meter ( $\text{g}/\text{m}^2$ ), this is well below averages for streams in similar ecoregions. Platts and McHenry (1988) reported averages of 7.71  $\text{g}/\text{m}^2$  for the Rocky Mountain ecoregion, 6.15  $\text{g}/\text{m}^2$  for the Colorado Plateau ecoregion, and 9.15  $\text{g}/\text{m}^2$  for the Gila ecoregion. Rudd Creek had the highest average trout biomass by reach with 3.3  $\text{g}/\text{m}^2$ ; followed by Nutrioso Creek with 2.2  $\text{g}/\text{m}^2$ , Colter Creek with 1.1  $\text{g}/\text{m}^2$ , and Benton Creek with 0.72  $\text{g}/\text{m}^2$ . These were all very low when compared to averages obtained from three nearby, high quality, lightly grazed, second order streams on the White Mountain Apache Reservation. These streams located in the Gila ecoregion, averaged 14.3  $\text{g}/\text{m}^2$  when surveyed in 1990 using the same methodology in this survey (Novy 1991).

Overall riparian and stream habitat conditions on the streams surveyed were fair using current Forest Plan standards and guidelines. HCI's below the minimum 60% occurred throughout all streams surveyed and all channel types, indicating the need to determine impacts from the entire watershed along with riparian and stream conditions. Improvement of overall watershed conditions, along with improvements in riparian and fisheries habitat would move conditions towards goals in the Forest Plan. Watershed improvements should include relocating, closing, stabilizing, and obliterating roads and stream crossings adversely impacting riparian and fisheries habitat. This along with stabilizing and revegetating headcuts, gullies, and unstable eroding streambanks, can significantly reduce sediment entering streams and help to restore degraded fisheries habitat. The development of grazing plans and other land use and management activities should allow for and maintain an HCI of at least 60% and satisfactory riparian conditions.

## Glossary

**Bank Angle** - The average of angles formed between the downward sloping stream banks and the water surface. If the stream bank is undercut, the angle is always less than 90 degrees, otherwise the angle is 90 degrees or greater. Valuable rearing habitat is lost if the bank has been cut away and moved back from the water column. Fish often congregate near undercuts and vertical banks.

**Bank Cover** - A rating of stream bank vegetation types. Brush is considered optimal and assigned the highest rating of 4. Forested is rated 3, grass and forbes is rated a 2, and exposed (rock or soil) is assigned the lowest rating of 1. The ratings are converted to a percentage of the maximum possible.

$$\text{Bank Cover\%} = \frac{\text{Sum of all bank cover ratings} \times 100}{8 \times \text{number of transects}}$$

**Bank Soil Stability** - A rating of the stream banks soil characteristics and ability to resist erosion. Plant density, rootmass, particle size composition, rawbanks and extent of erosion are considered in the rating of each bank. The ratings are converted to a percentage of the maximum possible.

$$\text{Bank Soil Stability \%} = \frac{\text{Sum of all soil stability ratings} \times 100}{8 \times \text{number of transects}}$$

**Bank Vegetation Stability** - A rating of the stream banks vegetation density and ability to resist erosion. Stream bank vegetation provides cover shade and a terrestrial food source for fish, as well as rootmass and soil cover to resist erosion from flowing water. The ratings are converted to a percentage of the maximum possible.

$$\text{Vegetation stability\%} = \frac{\text{Sum of vegetation stability ratings} \times 100}{8 \times \text{number of transects}}$$

**Canopy Density** - The percentage of sky over the stream channel which is blocked out by vegetation. A canopy provides shading of the stream which helps prevent water temperatures from increasing to critical levels for trout. Leaf drop in the fall can be a major energy source to the streams aquatic food web when a healthy canopy is made up of deciduous trees and shrubs.

**Embeddedness** - A rating of the amount of surface area of large size particles (gravel, rubble, and boulder) on the stream bottom which is covered by fine sediments. High silt levels inhibit successful spawning of trout, production of stream bottom macroinvertebrates and primary production of attached algae by covering rocky substrate. High embeddedness is also an indicator of unstable conditions upstream. The ratings are converted to a percentage of the maximum possible.

$$\text{Embeddedness \%} = \frac{\text{Sum of all embeddedness rating} \times 100}{5 \times \text{number of transects}}$$

**Gravel Bottom** - (stream bottom) The percentage of the stream bottom composed of gravel and rubble. These size particles are necessary for spawning and are the most productive in producing food (aquatic macroinvertebrates) for fish.

$$\text{Gravel bottom \%} = \frac{\text{Sum of gravel and rubble measurements} \times 100}{\text{Sum of water widths}}$$

**HCI** - (Habitat Condition Index) is a multi variate rating of existing trout habitat quality. It is computed using pool measure (PM), pool structure (PS), gravel bottom (GB), bank cover (BC), bank soil stability (BSS), and bank vegetation stability (BVS) ratings. The HCI increases as habitat quality increases.

$$\text{HCI \%} = \frac{\text{PM} + \text{PS} + \text{GB} + \text{BC} + \text{BSS} + \text{BVS}}{6} \times 100$$

HVI - The Habitat Vulnerability Index is a rating that predicts the vulnerability of stream habitat to management activities and natural occurrences. It is computed using valley bottom width (VWC), stream gradient (SGC), side slope gradients (SSC), lower banks type (LBC), bank stability (CSC), and indicators of potential sediment production (SPC) coefficients. The HVI increases as the streams susceptibility to damage increases.

$$\text{HVI \%} = \frac{\text{VWC} + \text{SGC} + \text{SSC} + \text{LBC} + \text{CSC} + \text{SPC}}{3 + 4 + 4 + 3 + 4 + 4}$$

Pool Measure - A rating of the pool - riffle ratio of the sample area. A fifty-fifty pool-riffle ratio is assumed to be the most productive. Pools provide resting and rearing habitat for fish, whereas riffles produce food and support trout spawning. The pool measure rating decreases as the pool-riffle ration deviates either direction from a fifty-fifty ratio.

$$P = \frac{\text{Total pool widths}}{\text{Total water widths}} \times 100$$

where P = 50, the rating is 100%

where P < 50, solve

$$\text{Pool measure \%} = 100 - [(50-P) \times 2]$$

where P > 50, solve

$$\text{Pool measure \%} = 100 - [(P-50) \times 2]$$

Pool Structure - A rating of pool quality which reflects the percentage of high-rated pool widths out of the total pool widths measured. Pools are rated by size, depth, and fish cover available. A good relationship exists between high quality pools and high fish standing crops.

$$\text{Pool structure \%} = \frac{\text{Total 1, 2, and 3 rated pools}}{\text{Total of all pools}} \times 100$$

PRA - Potential Rearing Area is the percentage of stream area with water velocities < 1 foot per second (pools). Small trout require these pools for rearing.

PSA - Potential Spawning Area is the percentage of stream bottom area composed of 1/8" to 3" diameter gravel. Trout require these gravels for spawning and embryo incubation.

Riffles - The percentage of stream area where water velocity is fast, stream depth is shallow and water surface gradient is steep. Riffles are the food (aquatic macroinvertebrate and periphyton) producing areas of a stream.

Riparian Condition - A rating of existing riparian conditions using the USFS Region 3 Riparian scorecard. Overstory, midstory, and understory conditions are all rated. Riparian vegetation is important in stabilizing stream banks, filtering eroded soil, blocking solar radiation, providing cover and a source of terrestrial insects for fish as well as providing organic input to the stream's aquatic food web.

Shore Depth - The average of water depths measured at the shoreline or at the edge of a bank overhanging the shoreline. Shore depth is critical for young-of-the-year fish. Valuable rearing habitat is lost when the banks have been cut away and there is zero shore depth.

Stream Channel Stability - A rating of 15 parameters describing upperbank, lowerbank, and stream bottom characteristics and stability. There has been a good relationship between these ratings and resident trout standing crops.

Undercut banks - The average of all undercut widths (the distance from the furthest point of protrusion of the bank to the furthest undercut of the bank) measured at each station. If no undercut is present at the transect, the undercut measurement is recorded as a zero. Undercut banks provide valuable cover for fish and provide conditions favorable to producing high trout biomass.

Ungulate Damage - A rating of observed bank damage caused by ungulates including trampling, removal of stream bank riparian vegetation, sloughing and bank erosion. The ratings are converted to a percentage of the maximum possible. Excessive ungulate damage destroys riparian vegetation, causes bank sloughing, increases sedimentation and embeddedness, causes the stream to widen and shallow resulting in an increase of water temperature.

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